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DETERMINING SEED-ZONE SOIL WATER CONTENT

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INTRODUCTION

The Food Security Acts of 1985 and 1990 Farm Bills require producers with highly erodible crop land (HEL) to have farm conservation plans for minimizing soil erosion in order to be eligible to participate in USDA programs. These farm plans include erosion control structures, green crop cover, surface residue, surface roughness, infiltration rate, and water storage practices. The use of residue from previous crops for erosion protection has contributed to production problems in some areas of the Columbia Plateau, where summer-fallow is rotated with winter wheat. These areas are usually associated with cool moist conditions in the fall. Downy brome control (Veseth et al., 1994) and Cephalosporium stripe (Veseth et al., 1993) are more difficult to control in tillage systems that leave residue on or near the soil surface. Because of these risks associated with surface residue, some farmers in Agronomic Zones 4 and 5 (Douglas et al., 1990) of the Columbia Plateau use green crop cover and surface roughness in addition to crop residue, satisfying erosion protection requirements of their conservation plans.

Early seeding to provide crop cover for erosion protection during late fall and winter period in the Columbia Plateau is not without risk. Seed-zone soil water for wheat germination and emergence may not be adequate in dry years (Klepper et al., 1988). If water is present, some wheat diseases are favored by early seeding (Smiley and Patterson, 1994). A deep-fine soil mulch (3 to 4 inches) provides seed-zone water conservation (Papendick et al., 1973) but these fine deep mulches are highly susceptible to erosion. Chemical fallow provides protection from erosion but does not maintain seed-zone soil water as compared to conventional summer-fallowed tillage. Summer-fallowed fields, even with fine soil mulch, continue to lose water from the seed-zone soil at high rates in the early fall (Pikul et al., 1985).

Management of summer-fallowed fields in the Columbia Plateau to minimize soil erosion and simultaneously maximize soil water content in this seed zone at the optimum planting date for maximum production is a series of compromises. Management is especially critical during dry years. An average last seeding date to obtain green cover requirements by December 1 is set by average air temperature. Before that date, inadequate stand is a problem that requires even earlier seeding to meet green cover requirements.

This work describes a technique used to determine if sufficient seed-zone soil water existed in summer-fallowed fields for winter wheat seedling emergence.

MATERIALS AND METHODS

Eight summer-fallowed fields that had green cover requirements for conservation plans were sampled in the dry fall of 1994 to evaluate seed-zone soil water content. Average annual precipitation in these fields ranged from 12.5 to 17 inches. Soil series in these fields were McKay, Morrow, Condon and Pilot Rock silt loams. Table 1 shows the field characteristics.

Table 1. Sample site characteristics. Umatilla County, Oregon

Site	Soil Series	Field Size	Slope Aspect†	Annual Precipitation	Sample Locations	Soil Depth
		acres		inches	number	inches
1	Pilot Rock	301	N, S, NE	15.5	8	24 - 48
2	Condon	236	W, NW, SW, NE	15.5	9	--
3	Condon	218	N, S, SE	15.5	9	16 - 36
4	Pilot Rock	384	N, E, S, SE	15.5	10	11 - 34
5	McKay	147	N, E	17.0	10	--
6	McKay	204	N, NW, NE, SW	17.0	10	--
7	Morrow	263	E, N, NE, SE	13.0	10	16 - 28
8	Morrow	444	N, NE, E, W, SW	12.5	10	30 - 40

† N = north, S = south, E = East, W = west, NE = northeast, NW = northwest, SE = southeast and SW = southwest.

A computer model PLANTEMP, (Rickman, et al., 1990) was used to calculate the average last seeding dates to have 20, 30, and 50 percent green cover at each site. Eighty percent emergence, 10,000 seeds per pound, daily average maximum and minimum air temperatures and daily average precipitation for each site (average air temperatures and precipitation were generated with "WEATHER WIZARD", Zuzel and Karow, 1988) were used in PLANTEMP to determine the average last seeding dates.

Soil samples were taken on September 12 at sites 1, 2, 3, and 4 and on September 14 at sites 5, 6, 7, and 8. Eight to ten field sample locations were chosen from areas with aspects and slopes that represented over five percent of the field. This procedure was chosen to provide a representative field average and field variability of soil water content in the surface mulch (0 to 3 inches) and seed-zone (3 to 6 inches). The number of sample locations from each area was proportional to the percentage of land in the field with that slope and aspect; for example, if 60 percent of the field sloped north with a 12 percent slope, 6 of the ten sample locations in that field were from that area. Five soil samples from two depths (0 to 3 and 3 to 6 inches) were composited for each field location. Samples were taken with a cylindrical core sampler 0.75 inches in diameter and 12 inches long and placed in soil sample bags. These samples were taken to the laboratory and weighed to the nearest 0.00002 lb (0.01 gram). Soil samples were oven dried at 140°F for at least 24 hours. Soil water content was calculated as percentage of oven dry weight.

RESULTS AND DISCUSSION

Table 2 shows the average last seeding date for each site. Seeding should be completed by September 10 and 20, respectively for sites seven and eight and sites one through six to get 20 percent green cover by December 1.

Table 2. Predicted seeding date to achieve 20, 30 and 50 percent crop cover by December 1.

Site	Row Spacing	Percentage Crop Cover On December 1 20	30	50
	inches	predicted date to seed†		
1, 2, 3, 4	12	Sept. 20	Sept. 10	Aug. 25
5, 6	10	Sept. 20	Sept. 15	Sept. 7
7, 8	14	Sept. 10	Sept. 1	Aug. 20

† PLANTEMP (Rickman et al., 1990) computer model was used with the following assumptions: Seeding rate = 80 lb/ac, kernels per pound = 10000, germination percentage = 80 percent, and sites one, two, three, four, seven and eight were considered dry sites (less than 15 inches of annual precipitation).

Table 3 summarizes the results of the soil water contents measured for the eight sites. With these soil water conditions is it reasonable to expect good stand establishments in these fields? Is there sufficient soil water to delay seeding so that disease incidence and severity are minimized (Veseth et al., 1993)?

Table 3. Soil water content for the top six inches in summer-fallowed fields in mid September 1994. Umatilla County, Oregon

Site	Soil	Depth: 0 to 3 inches Mean	Min.	Max.	Std. Dev.†	3 to 6 inches Mean	Min.	Max.	Std. Dev.
		% dry basis††							
1	Pilot Rock	5.8	4.5	6.2	1.1	13.0	10.2	18.5	2.4
2	Condon	4.5	3.4	5.2	0.7	12.0	9.3	14.5	1.8
3	Condon	6.3	4.6	8.0	1.2	14.1	10.9	16.3	1.7
4	Pilot Rock	6.6	5.3	8.9	1.1	13.8	11.7	15.8	1.6
5	McKay	9.0	6.6	11.1	1.4	22.0	17.4	25.0	2.4
6	McKay	7.3	4.9	10.7	2.0	16.3	11.9	19.3	2.3
7	Morrow	5.5	3.5	7.6	1.7	13.5	8.3	18.2	2.4
8	Morrow	7.0	4.6	9.9	1.6	11.2	7.1	15.6	2.6

† Std. Dev. = Standard deviation.

†† Oven dried 24 hours at 140°F.

Seed-zone soil water content should exceed nine percent (oven dry basis dried 24 hours at 240°F) for germination and emergence of winter wheat in a Ritzville silt loam soil (Lindstrom et al., 1976 and Wilkins et al., 1983). Morrow and Condon soils are very similar to Ritzville in water holding characteristics. Therefore, the 9 percent level should be applicable for Morrow and Condon soils. Pilot Rock and especially McKay soils have greater water holding capacity and require slightly higher percentage water (1/2 to 1 percent) for germination and emergence of wheat because the water is not as readily available.

Ideally, wheat seeds should be placed in soil with adequate water and not deeper than 2 inches. Seedlings forced to emerge from depths greater than 2 inches may be stressed and emergence may be reduced and delayed. Hoe type drills are ideal for seeding through deep-dry soil mulch because they can move dry soil away from the row. As much as 2 inches of soil can be moved from the row but in this process some dry soil is mixed into the seed-zone. A disadvantage with hoe and deep furrow drills is non-uniform seed depth placement. Disadvantages of disc drills are they tend to move more dry surface soil down into the seed-zone than hoe type drills, and they can not seed as deep as hoe drills (Wilkins et al., 1983).

It requires about one week with a mean daily temperature of 60°F to accumulate enough growing degree days for wheat to emerge (Klepper et al., 1988). During this week of emergence, as much as 2 percent seed-zone soil water will be lost through evaporation (Wilkins et al., 1983). Assuming a hoe drill is set to remove 2 inches of dry mulch and place the seed 2.5 inches deep (1.5 inches into moist soil) and accounting for soil drying and dry soil mixing during seeding, the minimum soil water content in the 3 to 6 inch zone should be 12 percent for silt loam soils.

The values in Table 3 were determined by drying at 140°F, but the 12 percent value was based on research when soil drying was at 220°F. Eight samples from four of the sites were dried an additional 24 hours at 220°F. An additional 0.9 percent water was removed. The lower limit of seed-zone soil water would be 11.1 percent (12.0 - 0.9 percent) for Morrow and Condon and slightly more for Pilot Rock and McKay soils (0.5 to 1 percent). This leaves no margin of error, such as hot dry winds during emergence or extra fine, dry soil sifting into the seed furrow. If the minimum soil water content in Table 3 is below 11.1 percent the portion of the field represented by that sample location would not have sufficient soil water for wheat emergence. The wheat may or may not emerge following fall rains.

The two McKay soils (sites five and six) have adequate soil water (Table 3). Site 5 could be seeded with a double disc drill provided disc penetration was sufficient to place seed 2.5 inches deep. Site 6 could be seeded with a hoe type drill by setting the drill to place seed about 4 inches below the original surface. Site 4 could be seeded deeply with a hoe type drill and expect good stand establishment. This site had the lowest standard deviation in water content in the 3 to 6 inch depth, indicating that conditions were uniform throughout the field at the 3 to 6 inch depth. Seeding would need to be done immediately or additional drying during September would reduce the soil water content below that necessary for emergence. Soil water evaporation rate remains high during the fall in summer-fallowed fields even though air temperatures are decreasing (Pikul et al., 1985).

Site 1 with Pilot Rock soil and site three with Condon soil have areas with seed zone water content below the threshold for wheat emergence. Site 1 was highly variable in soil water content in the 3 to 6 inch layer (Table 3 shows a standard deviation of 2.4). Site 3 had a mean soil water content of 14.1 percent in the 3 to 6 inch layer but there were areas in the field where soil water was below 11.1 percent. Either seedling establishment would be delayed and reduced because of deep seeding or areas within the fields would be void of seedlings because of a dry seedbed.

The fields with Morrow soil and site 2 with Condon soil could not be successfully sown because there is not sufficient soil water in the seed-zone throughout these fields to get uniform stand establishment. These fields could be "dusted in" but germination and emergence would not begin until rain wet the seedbed. Twenty percent green cover would not be achieved if rain was after September 20 (Table 2).

CONCLUSIONS

A technique for measuring soil water content in the seed-zone to determine if wheat establishment would be successful was demonstrated. Compositing five samples for each of two depths (0 to 3 and 3 to 6 inches), from 8 to 10 representative locations within a field gave a reliable measure of seed-zone soil water content and variability. This method could be used to determine the risk of obtaining poor stand establishment from delayed seeding.

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